while for Messier 33, 51, and 81 this additional motion is outward. But in all these cases the component perpendicular to the arms is small and well within the limits of errors.

The close agreement of the direction of the displacements with the spiral arms suggests that we may have here a realization of the motions described by Jeans in his *Problems of Cosmogony and Stellar Dynamics*, freely quoted in the following lines. If so, we must suppose that before the formation of the spiral arms the nebular masses were rotating and had reached a lenticular shape. The formation of Laplace's ring requires perfect symmetry of the mass about the axis of rotation. The distances of adjacent masses in space are in general so great that their gravitational influence will be extremely small, but even the slightest external gravitational field will be sufficient to preclude the formation of a ring; instead of this the matter will be thrown off at two antipodal points. The first elements of matter thrown off from these two points form in themselves a tide-generating system and the region of ejection will concentrate more and more at two points as the motion proceeds. The result is the extension further and further in the equatorial plane as the evolution of the nebula proceeds. The determination of the shape of the arms seems to be, at present, beyond the reach of mathematical analysis, but the long streams of gas must become longitudinally unstable and will tend to break up into condensations or nuclei.

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Mount Wilson Observatory, July, 1921.

RUBIDIUM IN THE SUN*

Dr. M. N. Saha[1] predicts that the principal lines of rubidium, which are invisible in the solar spectrum, should appear faintly in the spectra of sun-spots.

The search for them is made an easy matter by the recent publication of extensive and accurate tables of wave-lengths in the extreme red, both in the solar spectrum and in the arc, and by the existence at Mount Wilson of a fine set of plates of the spot spectrum extending to λ8200, taken by Mr. Brackett with the 150-foot tower telescope and 75-foot spectrograph, in the first order, with Nicol prism and compound quarter-wave plate.

On examination of these plates rather conspicuous spot-lines

[1]*Phil. Mag.*, **40**, 814, 1920.

were seen very near the known positions of both lines of the principal pair of rubidium. These lines are strictly confined to the spot, are rather diffuse, show a strong Zeeman effect, and resemble in all particulars the well-known lithium line at λ6708.

Measures were made upon two plates, using as standards a number of solar lines from Meggers' Table[2], with the following results:

Sun-Spot I. A.	Intensity	Rubidium Arc[3] I. A.	Intensity
7800.29	1	7800.29	10
7947.64	0	7947.64	8

The probable error of the measures, as indicated by the standard lines, is about ±0.01 A. The stronger line was measured on two plates. It is also the stronger of the two in the rubidium spectrum.

The presence of rubidium in the Sun appears to be established. The lines in question are the first pair of the principal series and are analogous in all respects to the D lines of sodium, appearing alone when the concentration of the metallic vapor is small.

No trace of the second pair of the principal series at λ4215.57 and λ4199.85 is visible in the spot-spectrum, but this is not surprising, for the corresponding pair of potassium lines is very faint, while the potassium lines in the red are strong.

It may be added that all these potassium lines are greatly strengthened in the spots, as predicted again by Saha, and that the same is true of the infra-red pair of the diffuse series of sodium at λλ8194, 8183. The lines of the subordinate series of potassium do not appear in either Sun or spot, nor do those of lithium (including the infra-red lines λ8126).

All these facts are in excellent agreement with Saha's theory of ionization. The familiar lines of the alkali metals are absorbed only by the un-ionized atoms. Sodium is considerably ionized at the temperature of the photosphere, potassium much more—leaving few absorbing atoms and not enough to produce the subordinate series—and rubidium so completely that its lines disappear. At the lower temperature of the spot, the ionization is less, the lines of sodium and potassium are strengthened, and those of rubidium appear.

Lithium, however, has a higher ionization potential than sodium, and must be less ionized both in the photosphere and the spots.

[2] *Publ. Allegheny Obs.*, **6**, 12-44, 1919.
[3] Meggers, *Bull. Bureau of Standards*, **14**, 383, 1916; *Scientific Papers*, No. 312.

The absence of its lines in the former and the faintness in the latter can be accounted for by the reasonable assumption that only a small amount of the element is present in the solar atmosphere. The principal lines of caesium are λλ8943 and 8521, well in the infra-red. Photographs of the region including the more refrangible of these will be made when opportunity offers.

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Mount Wilson Observatory, July 2, 1921.

THE DIAMETER OF ALPHA SCORPII BY THE INTERFEROMETER METHOD*

Observations of stellar diameters up to May 31st were given in the June number of these PUBLICATIONS. Additional measures have since been made of *Arcturus*, *Antares*, and other stars.

Arcturus, under improved conditions of seeing, showed weak residual fringes at 19.6 feet, the limit of the beam, and it is estimated that they will vanish at 21 feet. Using a value of λ = 5600 A, the revised angular diameter is 0″.022. According to van Maanen and Russell the most probable value of the parallax is 0″.095; the corresponding linear diameter is 21,000,000 miles.

Antares lies so far to the south that its images are drawn out into spectra by the Earth's atmosphere. There seems, however, to be no difference between the results obtained by direct observation and those with a deep yellow filter. The fringes disappear at 11.5 feet, but to make allowance for the influence of seeing, as described in section 2 below, the value adopted is 12 feet. Assuming λ = 5750 A (Class Ma), the value of the angular diameter is 0″.040. Russell's predicted value for this star is 0″.028; the value derived with the aid of the measure of α *Orionis* is 0″.039. There is some question as to the value of the parallax. If it is assumed that α *Scorpii* belongs to the *Scorpius* group, the resulting value of the parallax is 0″.0085 and the diameter 430,000,000 miles. If, however, we give the same weight to this value and to the mean of the measured parallaxes, we find 0″.013, and for the diameter 280,000,000 miles. Either of these values is greater than that obtained for *Betelgeuse*, namely, 218,000,000 miles, which depends on an angular diameter 0″.047 and parallax 0″.020.

In fair seeing β *Pegasi* (magnitude 2.6) has shown no fringes beyond 18 feet, but the images are a little faint and further observations will be necessary to check this result.